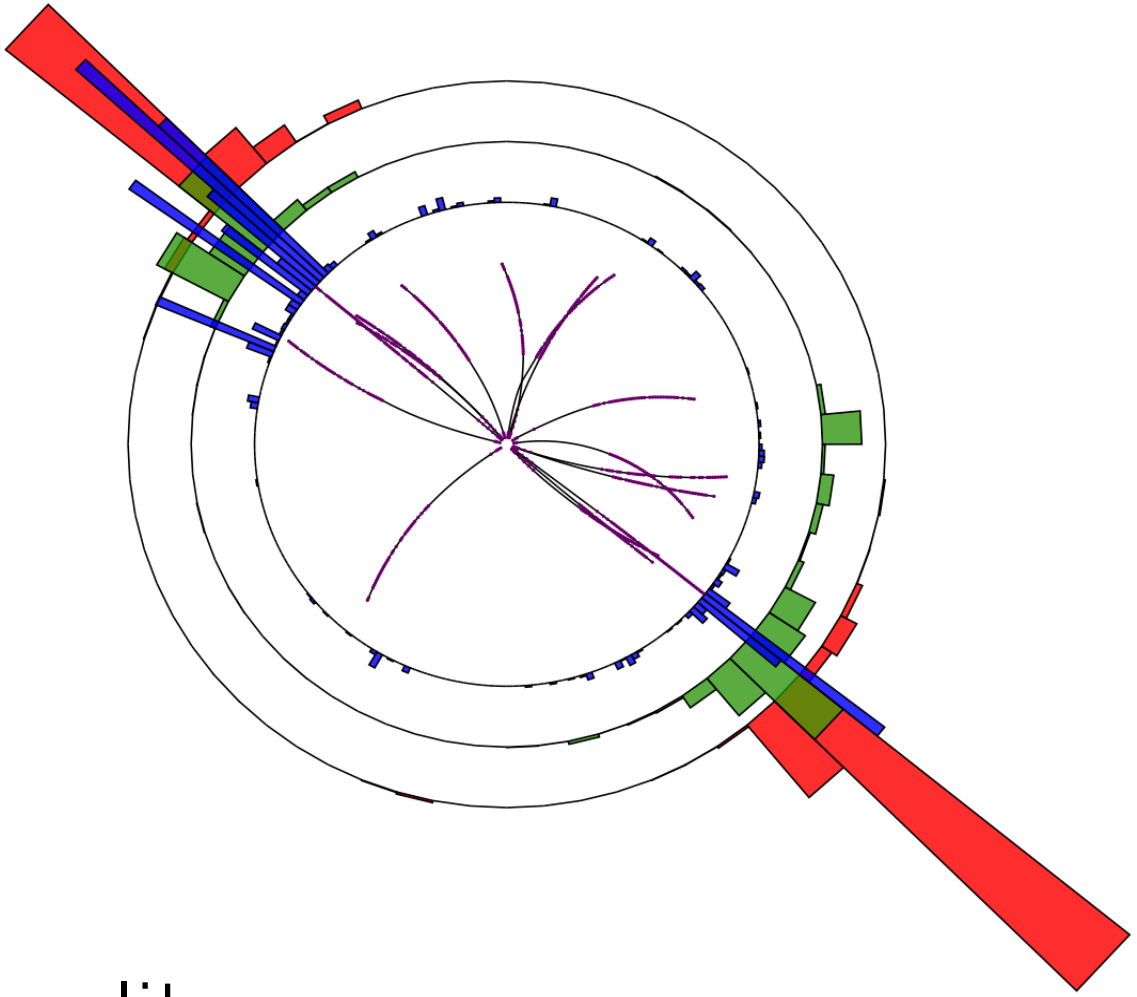
Report from the JS TG

4th sPHENIX Collaboration Meeting

BNL, June 13th,2017



Rosi Reed

Dennis Perepelitsa

LEHIGH UNIVERSITY

Outline

- Simulation update
- We've made jet background subtraction great again!
- Performance Plots
  - Jets
  - Photons
  - Associated Note is in Progress
- Selected observables

Detector Updates in Simulation

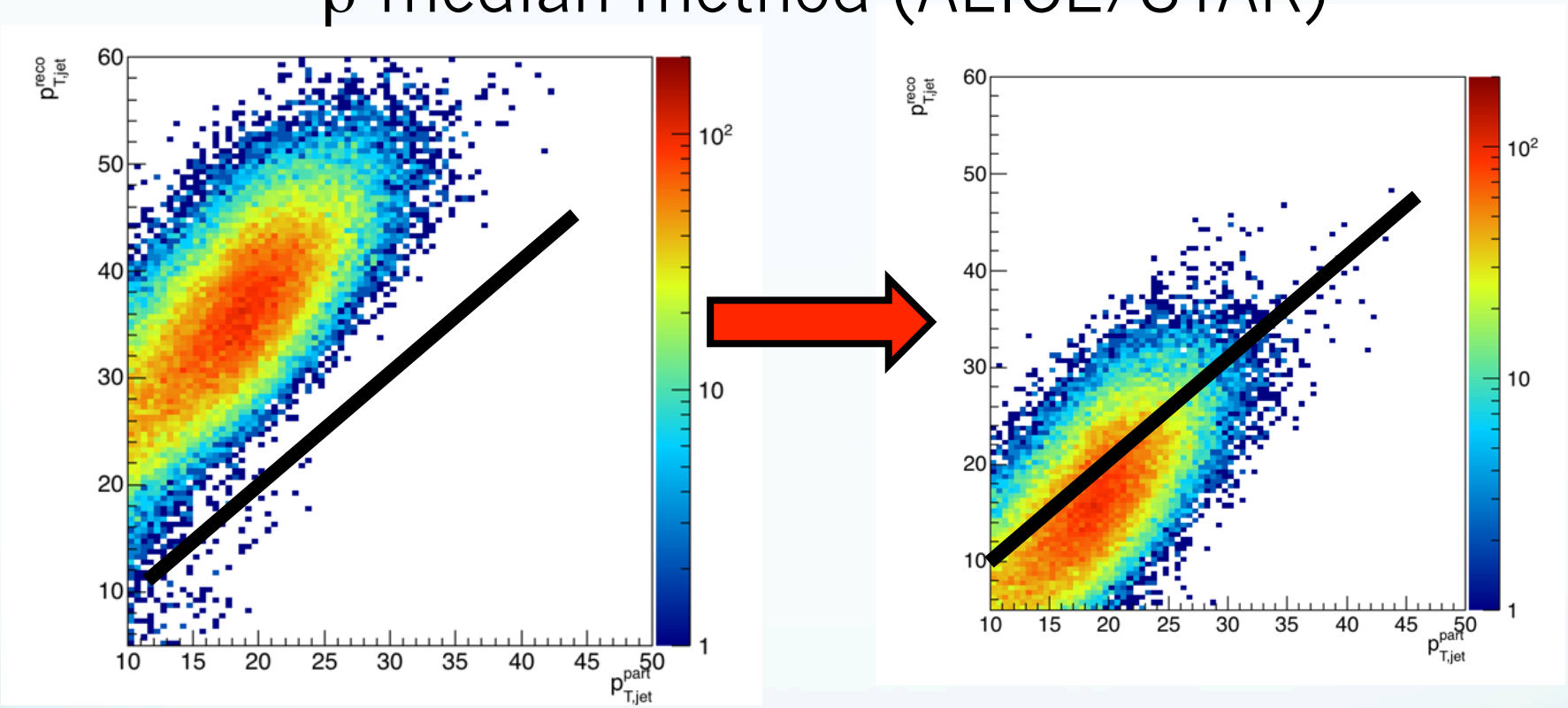
- Major update to the EMCal simulation
  - Description is at:
    - https://github.com/sPHENIX-Collaboration/coresoftware/pull/300
  - Introduced tilt of the 2x2-tower SPACAL modules
  - Included features learned from 2016 test beam data
  - Other key construction features (see Anne's talk)
- Much work has been done on the tracking simulation (see Tony's talk)
  - Key for the "structure" part of Jet Structure
  - Will be incorporated in the future now that the configuration is settled

Background Subtraction

- A key component of developing robust jet observables in HI collisions is the background subtraction method
  - **Correction to the JES** → Necessary for unfolding
  - Many different algorithms on the market
    - Can depend on the observable
  - Can reduce the contribution from combinatorial jets
- Note: Jet structure measurements can also require background subtraction to their components → Can be different than the JES correction

JES Correction – Toy Study

ρ median method (ALICE/STAR)



- PYTHIA jets $15 < p_{T,hat} < 25$ GeV "Background" thrown with a Boltzmann distribution
- Subtraction removes most of the offset in the JES
  - Observables still require unfolding

Background Subtraction

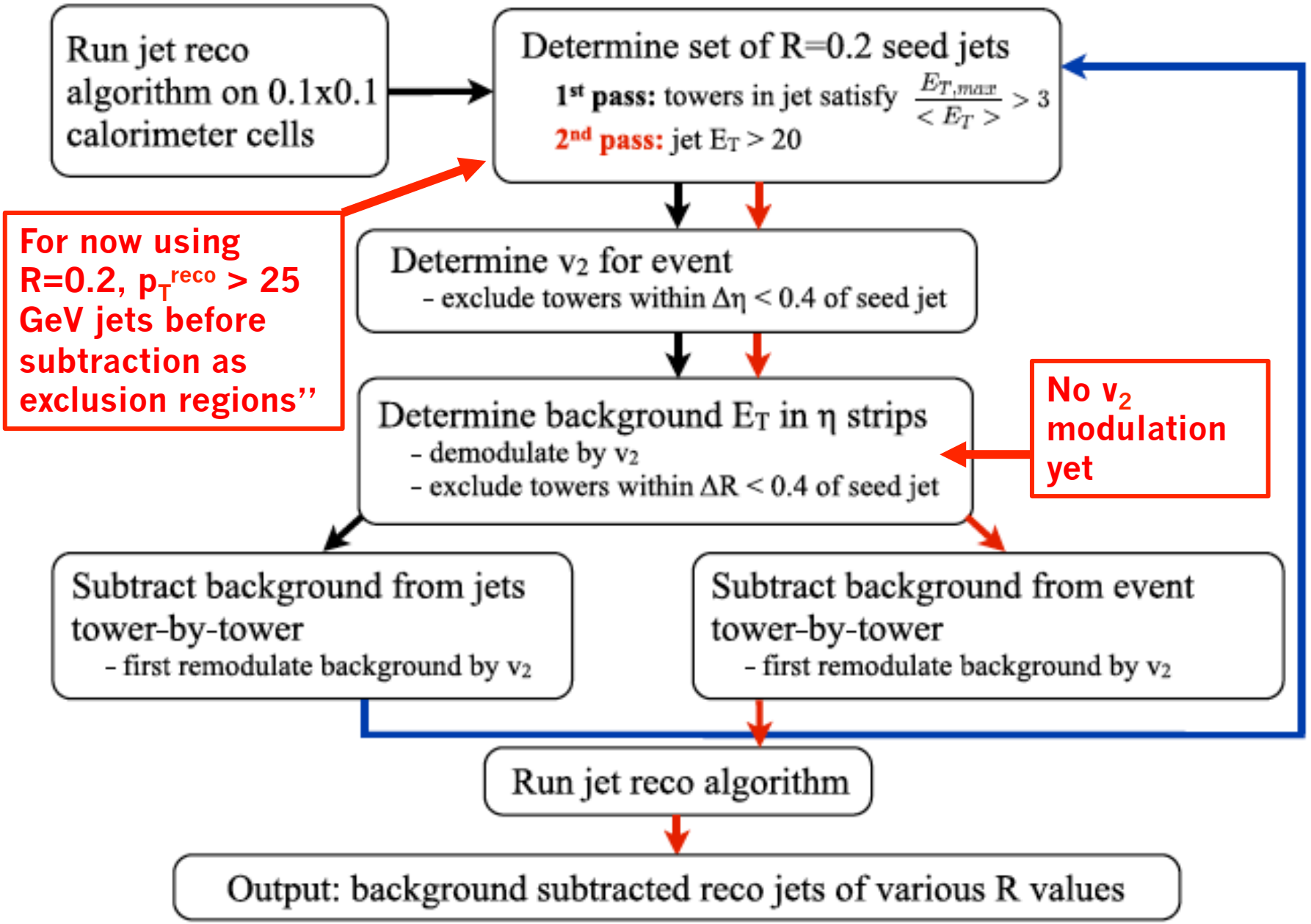
- For sPHENIX MIE, subtraction routine from *arxiv:1203.1353* was used
  - Lost in the separation of PHENIX and sPHENIX software
  - Healthy development of sPHENIX code meant this required a rewrite from scratch
  - Other background subtraction methods will be incorporated → Important for continuity
- First results with current geometry and reinstated background subtraction routine look promising

Background Subtraction

Iterative Atlas *arxiv:1203.1353*

- First results look promising
- We are continuing to work on this → 2 features not yet implemented:
  - Refinement of exclusion region definition in first iteration step
  - flow estimation / modulation
    - HIJING events used in the simulations shown here did not have flow modulation
  - However, we encourage people to test it out and send comments!

arxiv:1203.1353



Background Subtraction

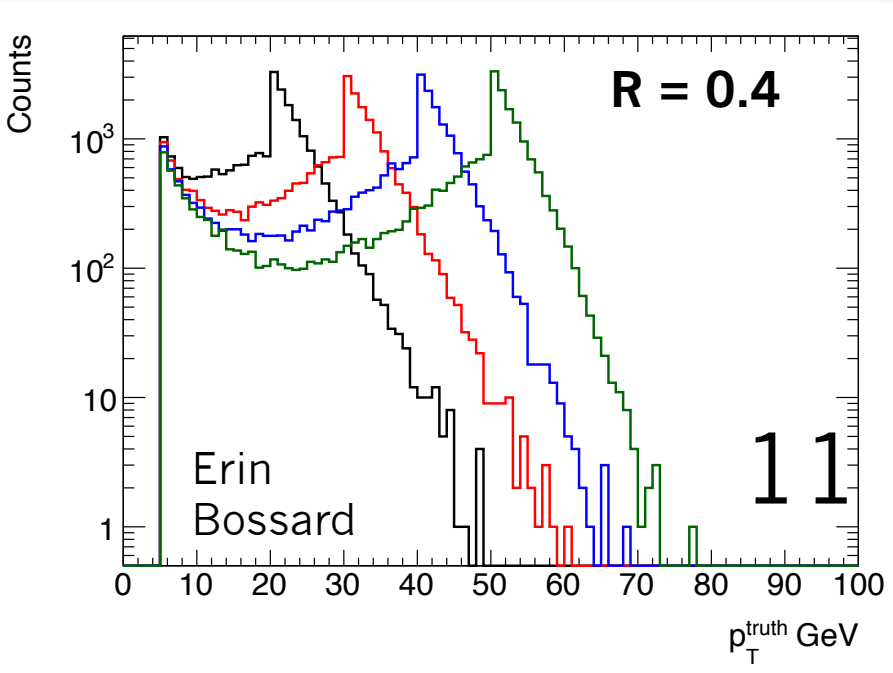
- Enabled by setting the **do_Hljetreco** flag in the master macro
  - Creates 0.1x0.1-towerized version of CEMC
  - Requires creation of towers from all 3 calorimeters subsystems
  - Requires default jet reconstruction
  - Estimates UE contribution to towers in η=0.1 rings
    - Separate for each layer
    - Writes info to node tree
  - Creates new UE-subtracted tower containers
- Jet reconstruction has been modified to handle negative-E tower inputs

Background Subtraction

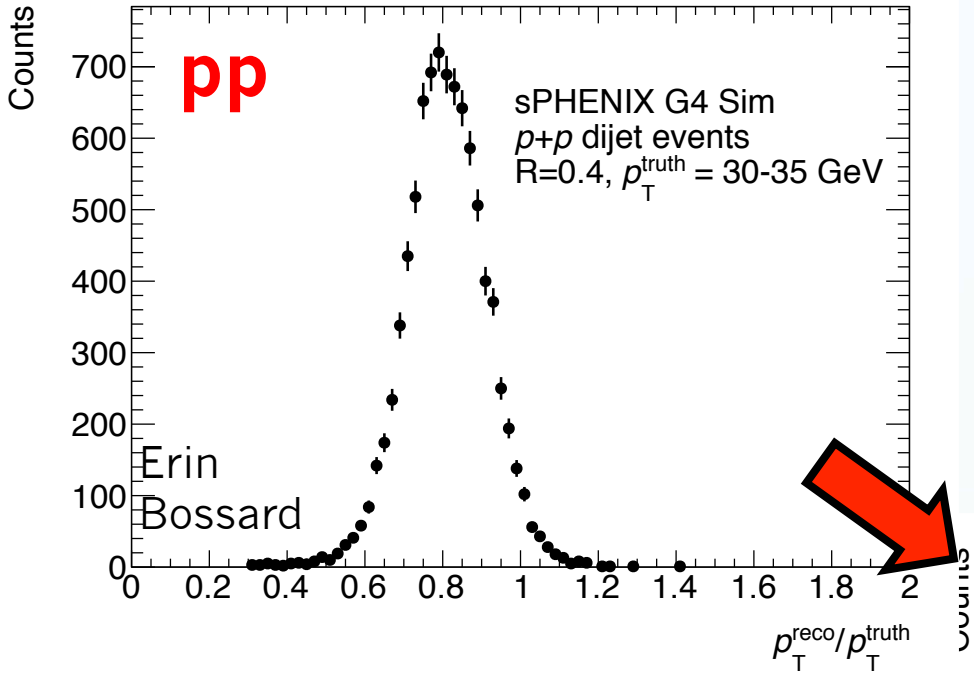
- To quantify the effect required realistic simulated background events
  - Single particle+HIJING
    - $V_z = 0$
    - b=0–4 fm (~0-7%)
    - /sphenix/data/data02/review_2017-08-02/sHijing/fm_0-4/
    - Note: |Vz| < 10 cm data can be found at:
      - /sphenix/data/data02/review_2017-08-02/vtx_z_10

Background Subtraction

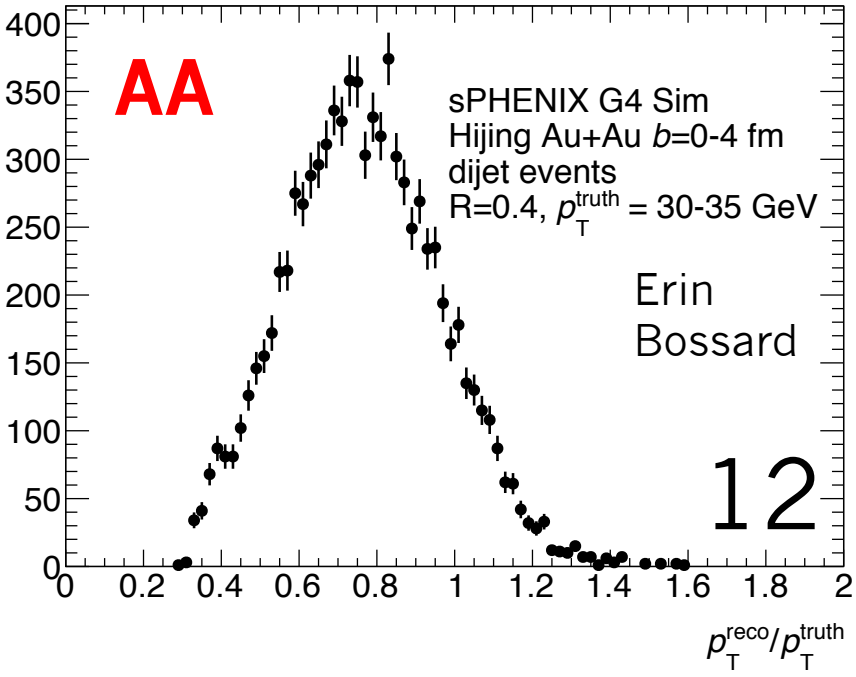
- Jets/γ-jet events with reasonable kinematics are embedded into the background
  - HepMC events are at /sphenix/user/dvp/gen/
  - 4 sets hard-scattering Pythia8 events
    - Filtered at the truth-jet level
    - Used in the p_T range where there is an unbiased falling p_T spectrum
- Look at JES/JER
- Extend to Calo based Observables



Jet Response

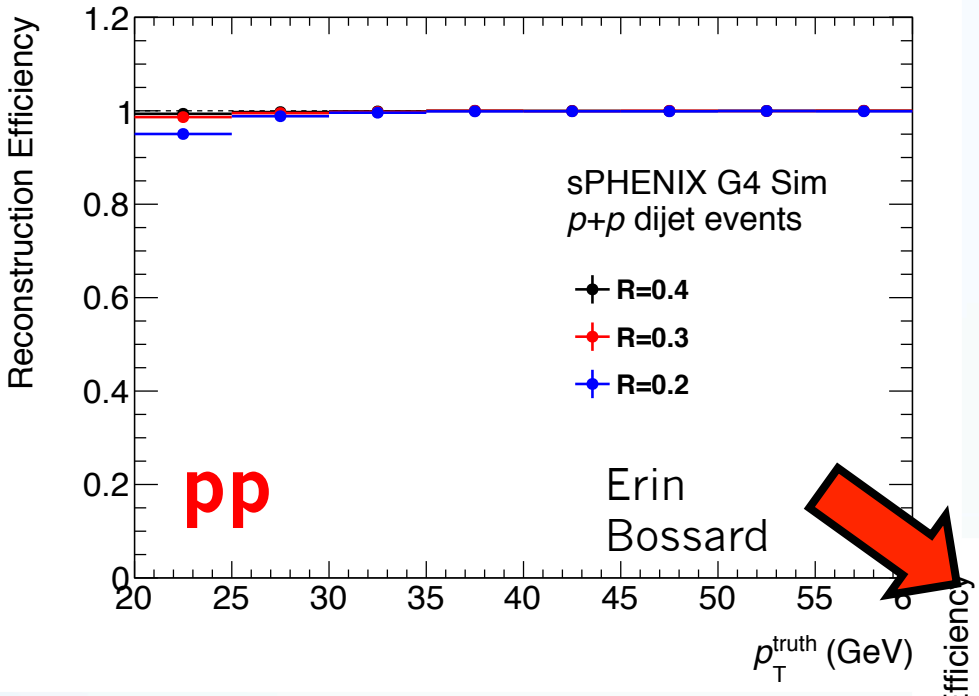


- Background smears reconstructed momentum
  - Increases JER
  - Depends on R and p_T
- Can decrease reconstruction efficiency

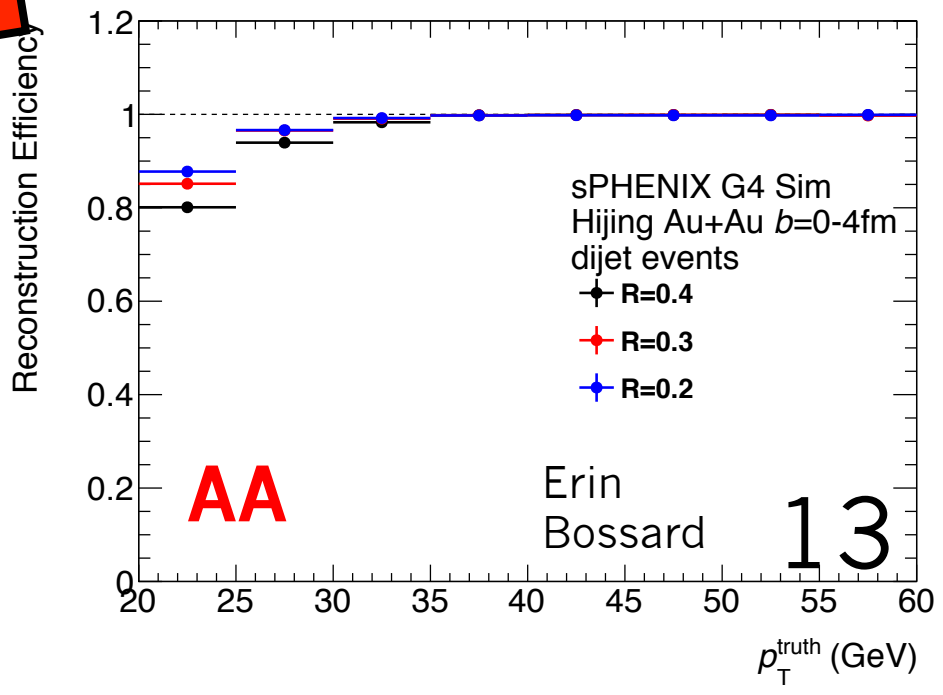


- Jet energy Scale (JES)
  - Increased by background
  - Subtraction method necessary
  - Unfolding requires well behaved Response Matrix

Reconstruction Efficiency

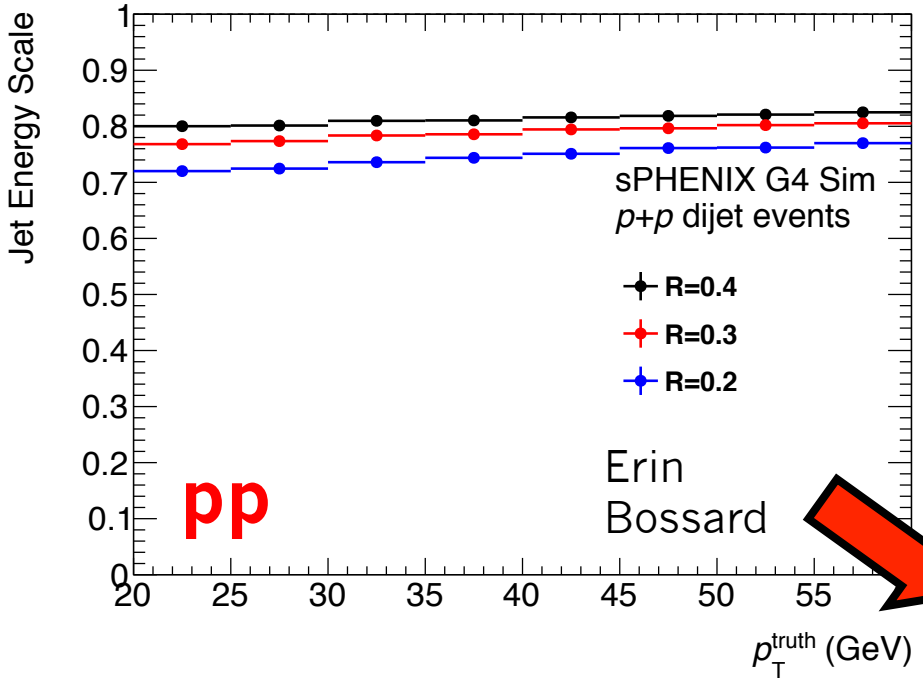


- Truth jets are association with closest reco jet within $\Delta R < R^{anti\text{-}kT}$
  - If this fails, the jet is not reconstructed



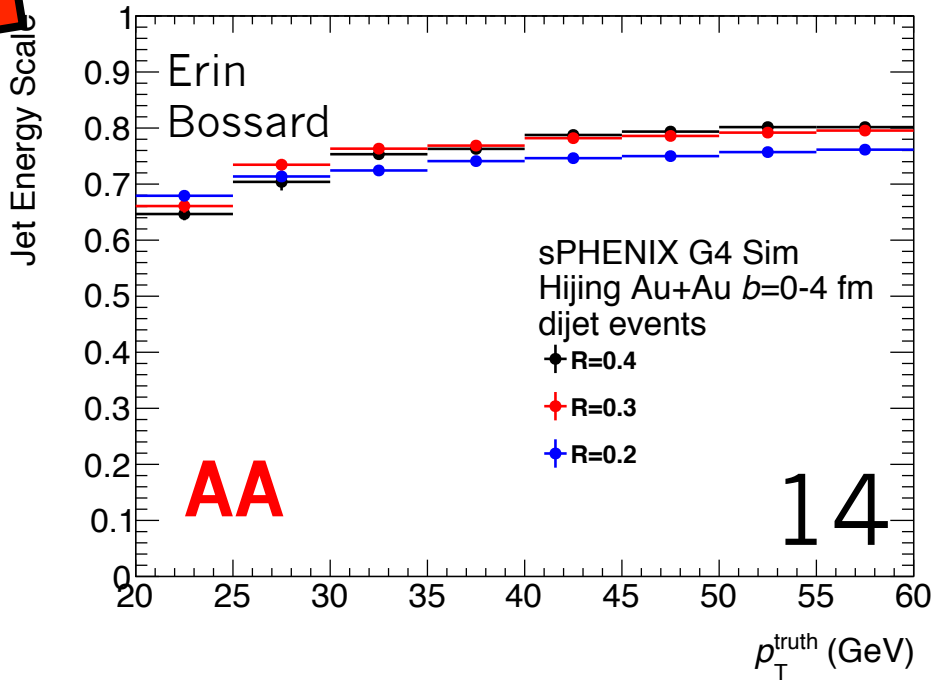
- Larger jets and lower p_T jets can be obscured by the fluctuating background

Jet Energy Scale

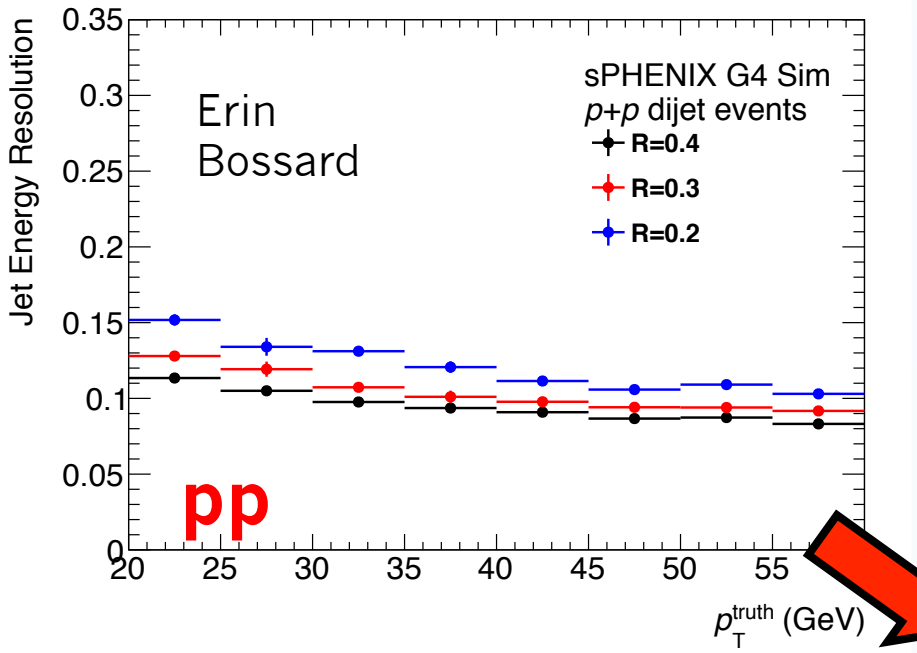


- For high momentum jets, the JES is similar in pp and AA
- Defect in the JES at low-p_T in AA → suspect cause is the crude exclusion seed selection
  - Low-p_T (hard scattering) jets are included in the estimate of the background → over subtracting

- Mean value of: $p_{T,reco}$ / $p_{T,truth}$
  - Determined by Gaussian fit
- Uses default simulations
  - Linear tower calibration → assumed sampling fractions
  - no additional jet-level calibration

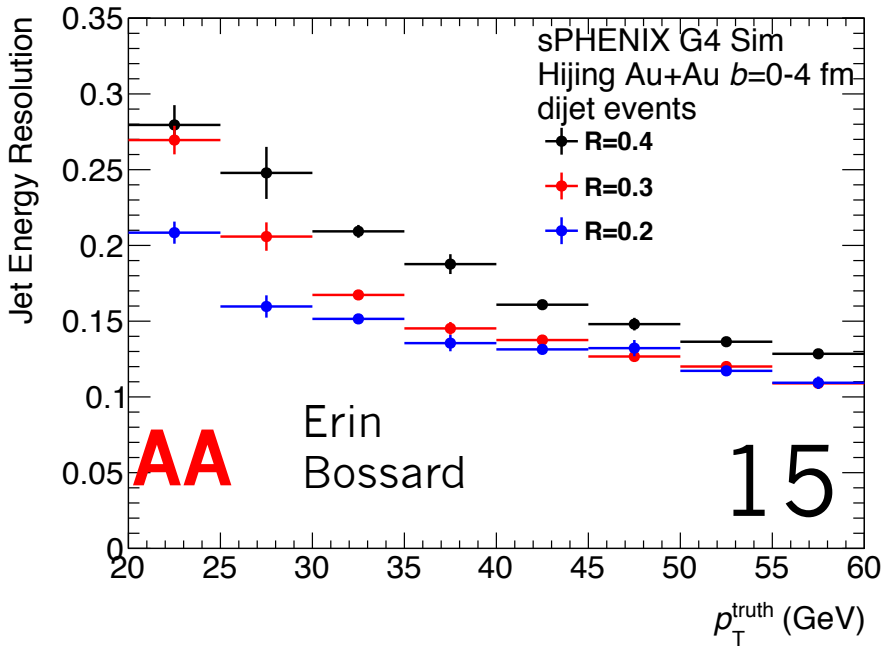


Jet Energy Resolution

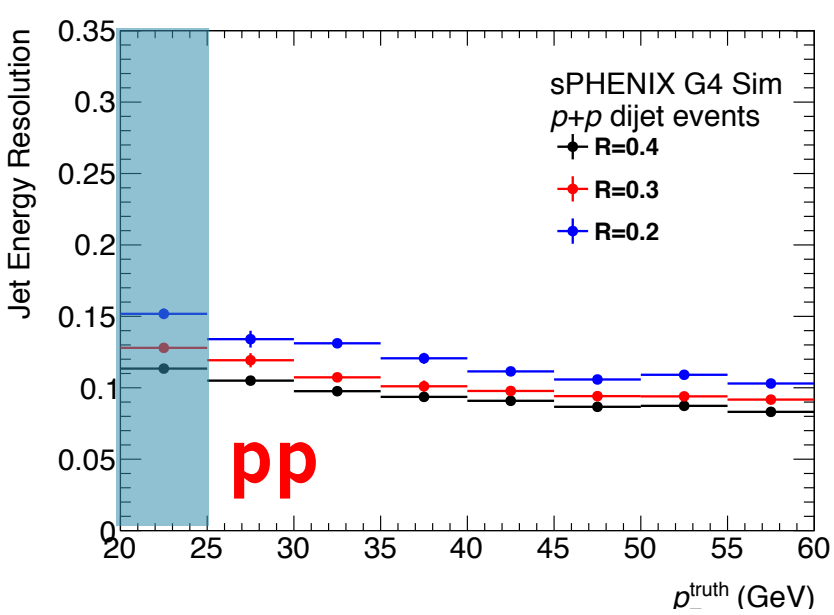


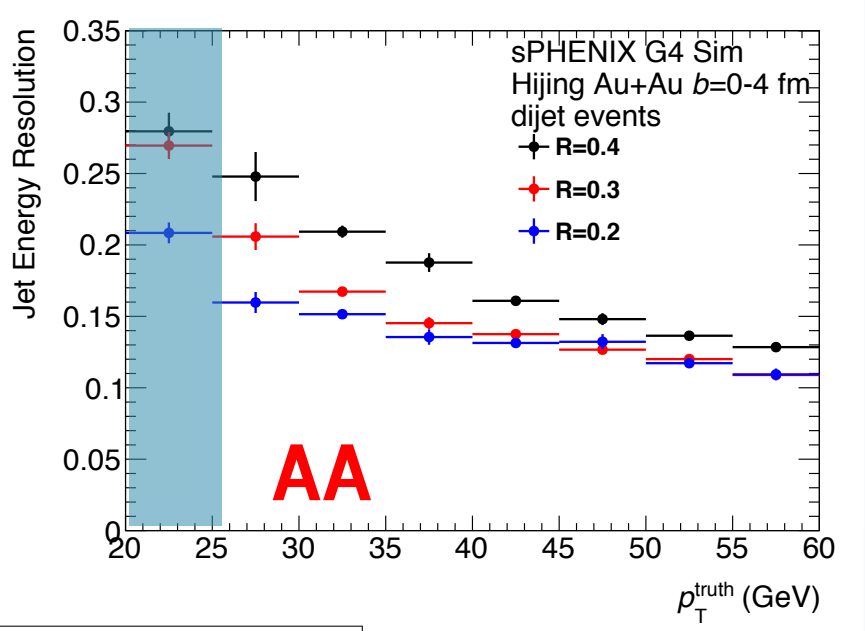
- In HI collisions JER increases with increasing R
- Rapidly increases for $p_{T,truth}$ ~ average background

- Width of $p_{T,reco}$ / $p_{T,truth}$ distribution
  - Determined by Gaussian fit

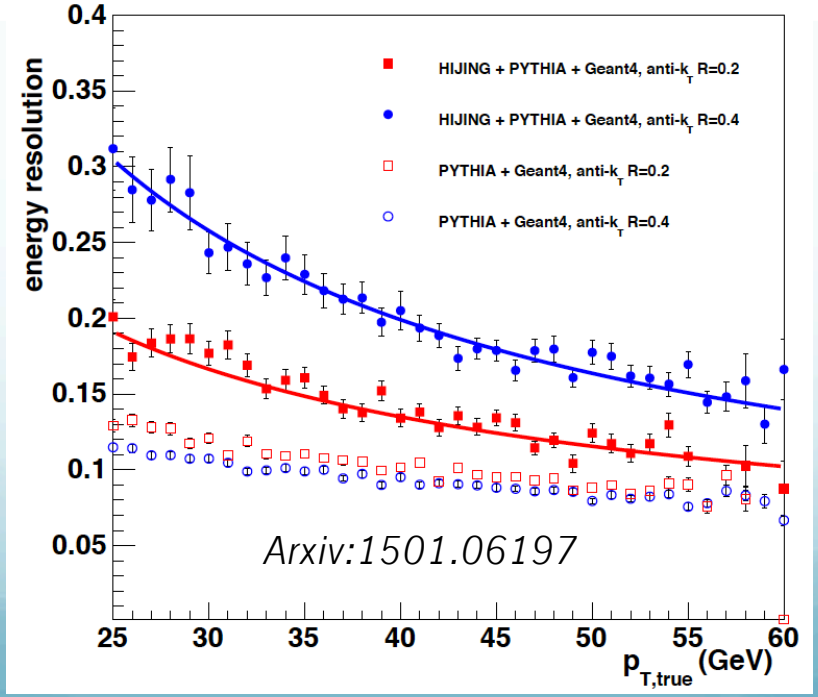


Jet Energy Resolution





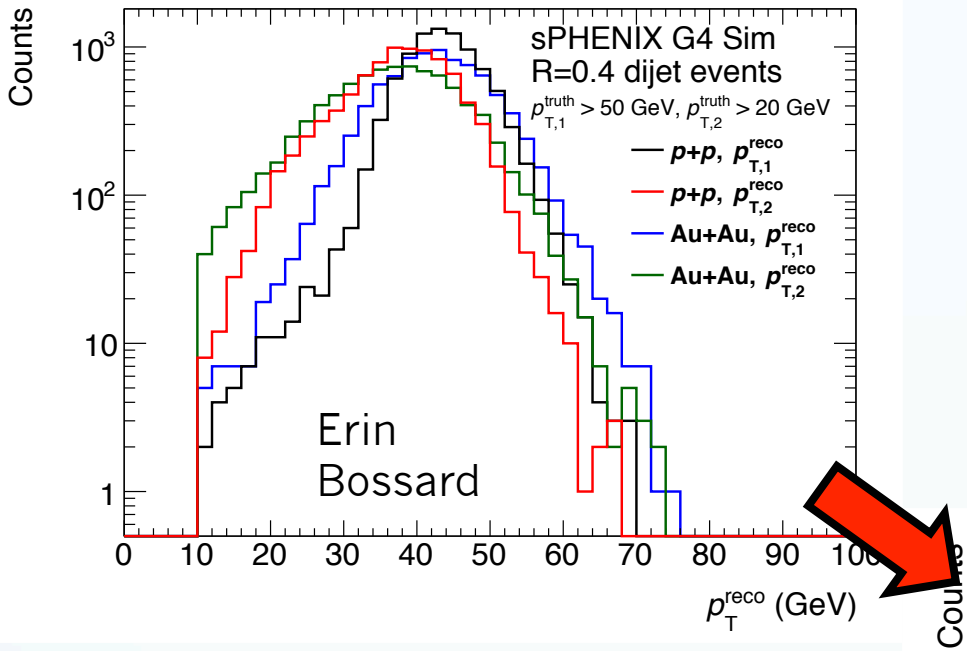
Despite all the changes in the software and the simulation geometry, **results are in good agreement!!** ☺



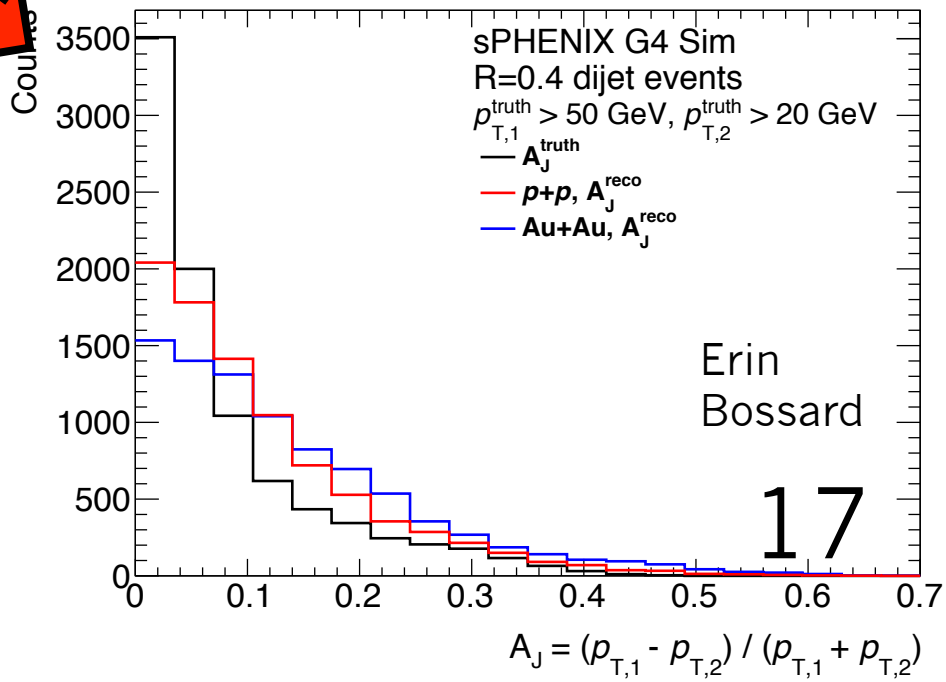
Note: JES is non-unity

- Unlike the MIE
- Correction would cause the JER to look even more similar

Dijet asymmetry A_J

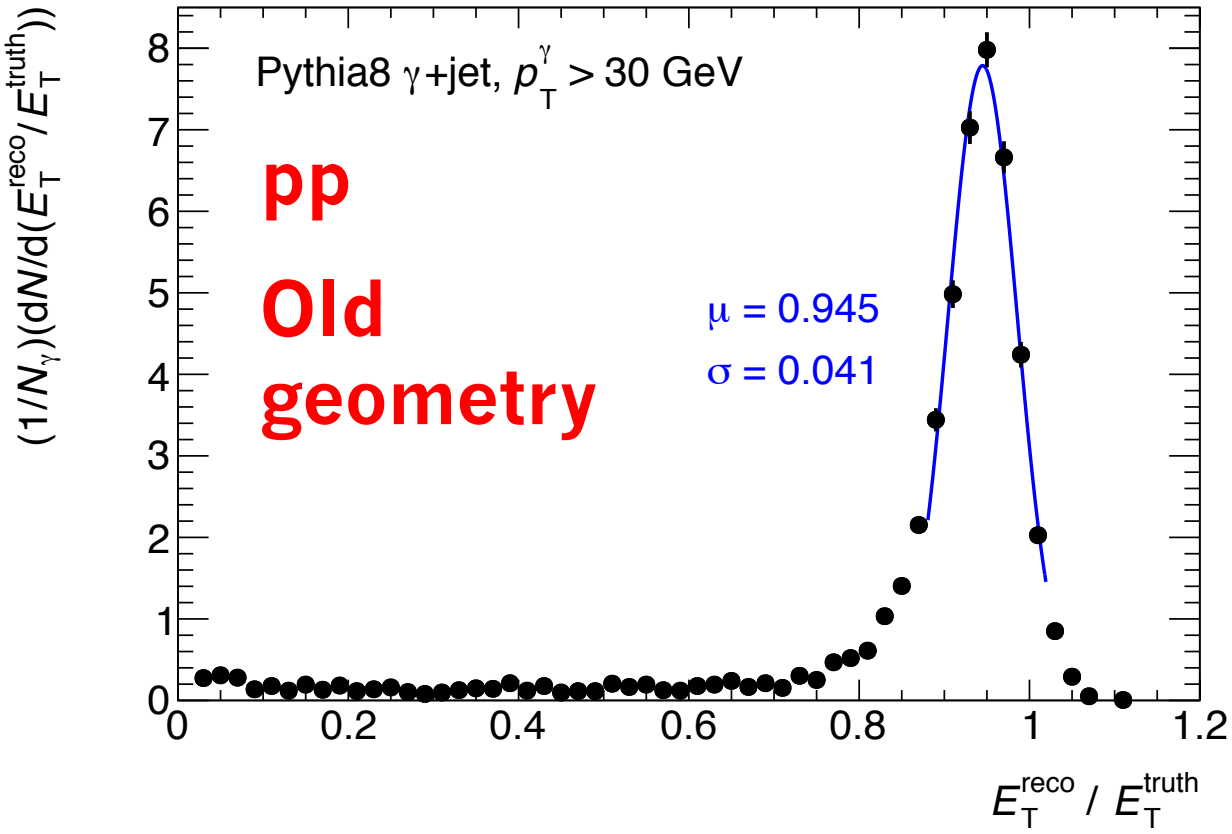


$$A_J = \frac{p_{T,1} - p_{T,2}}{p_{T,1} + p_{T,2}}$$



Demonstrates the magnitude of the detector and UE effects for an example observable

Photon Performance

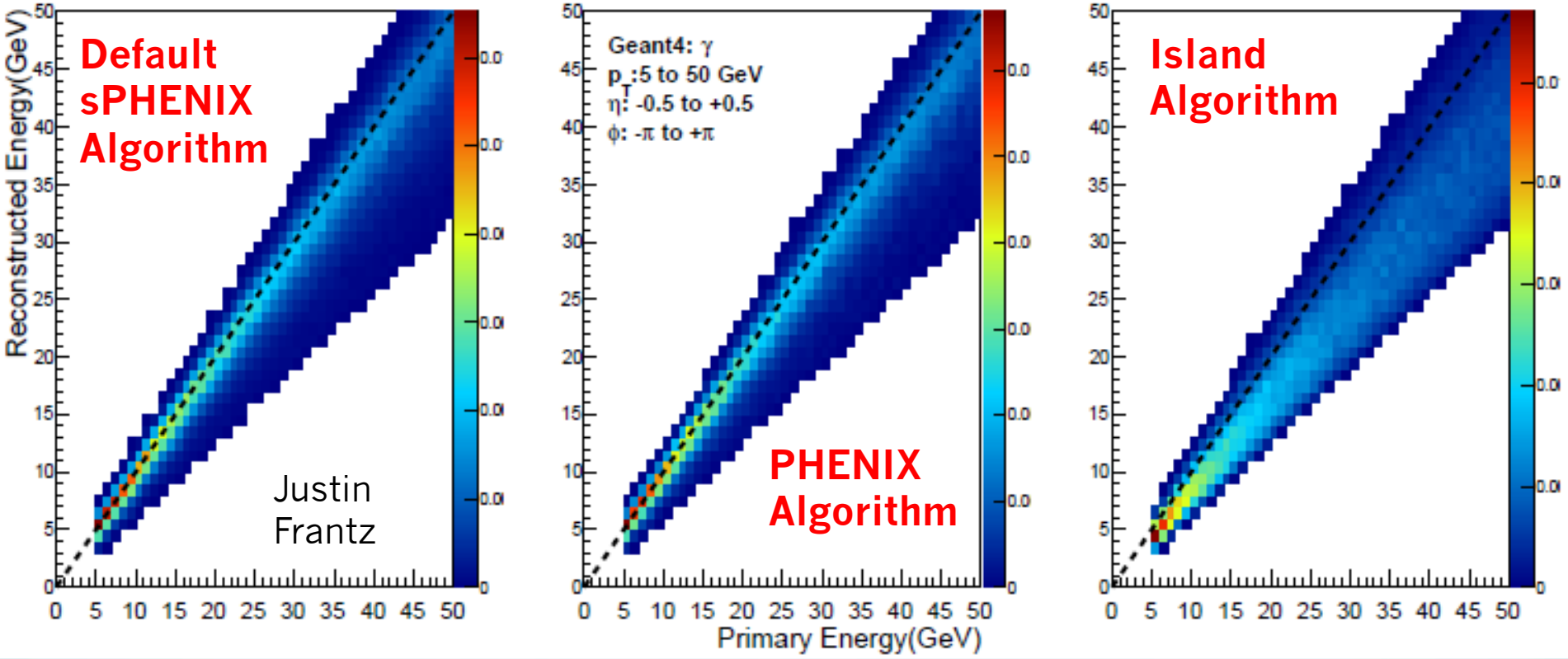


- γ-jet analyses are a key JS physics probe
- γ grants external handle on initial hard scattering

- Changes in the EMCal geometry could effect photon performance
- HI Clusterizers are under investigation

γ Reconstruction with Updated Geometry

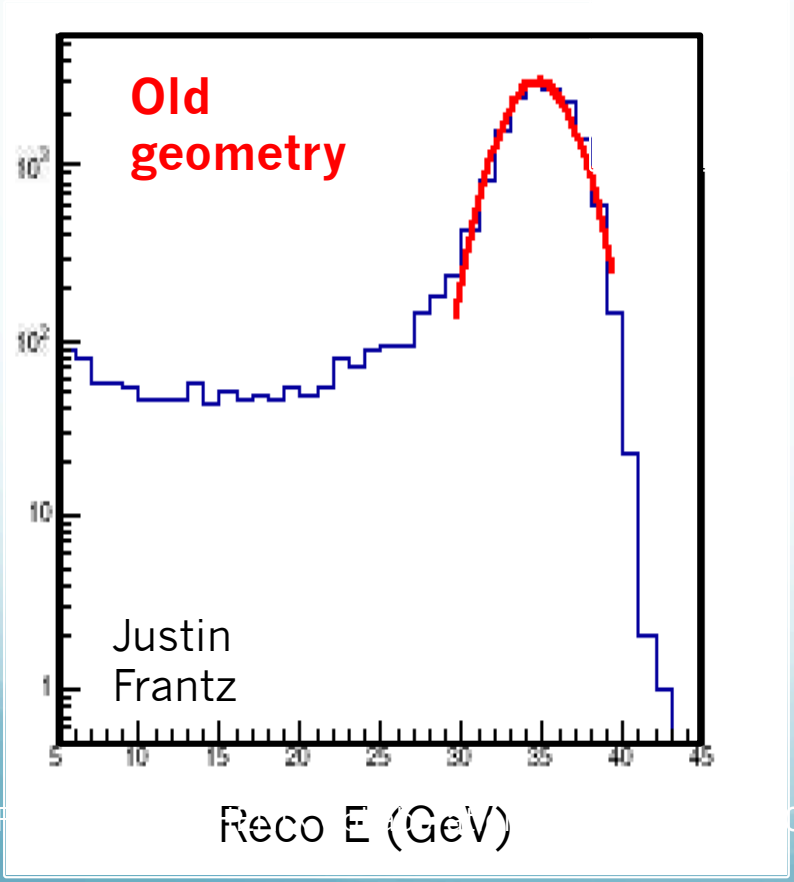
Single Particle

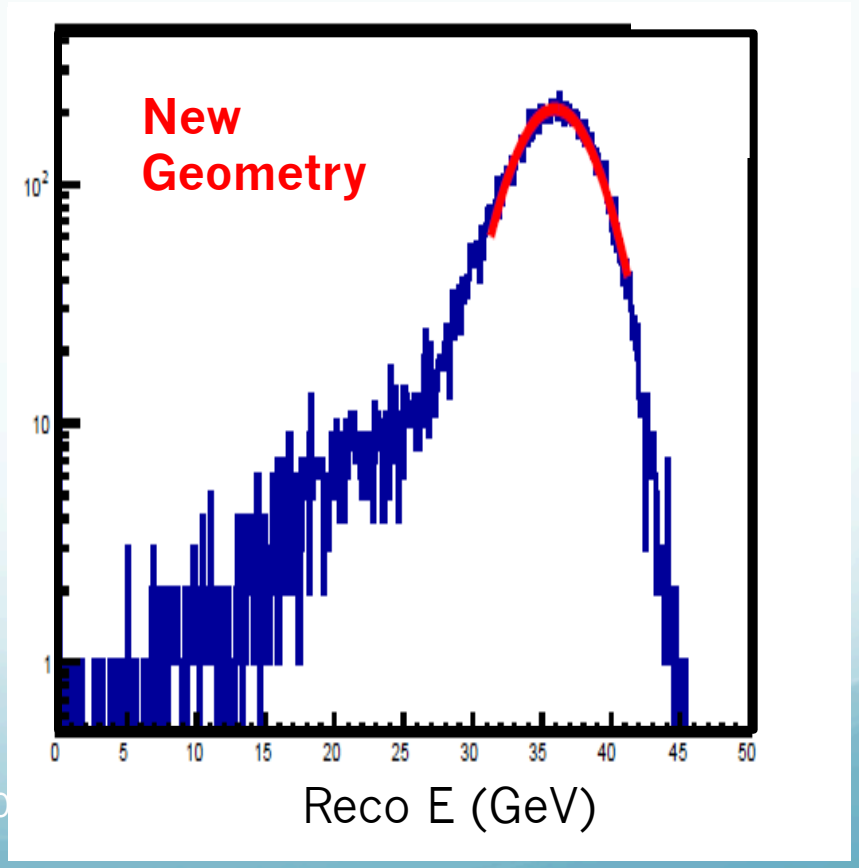


- New EMCal geometry did not change the response appreciably
  - New geometry improved the problem of low E
- Cut on low E clusters with reco/truth < 0.65

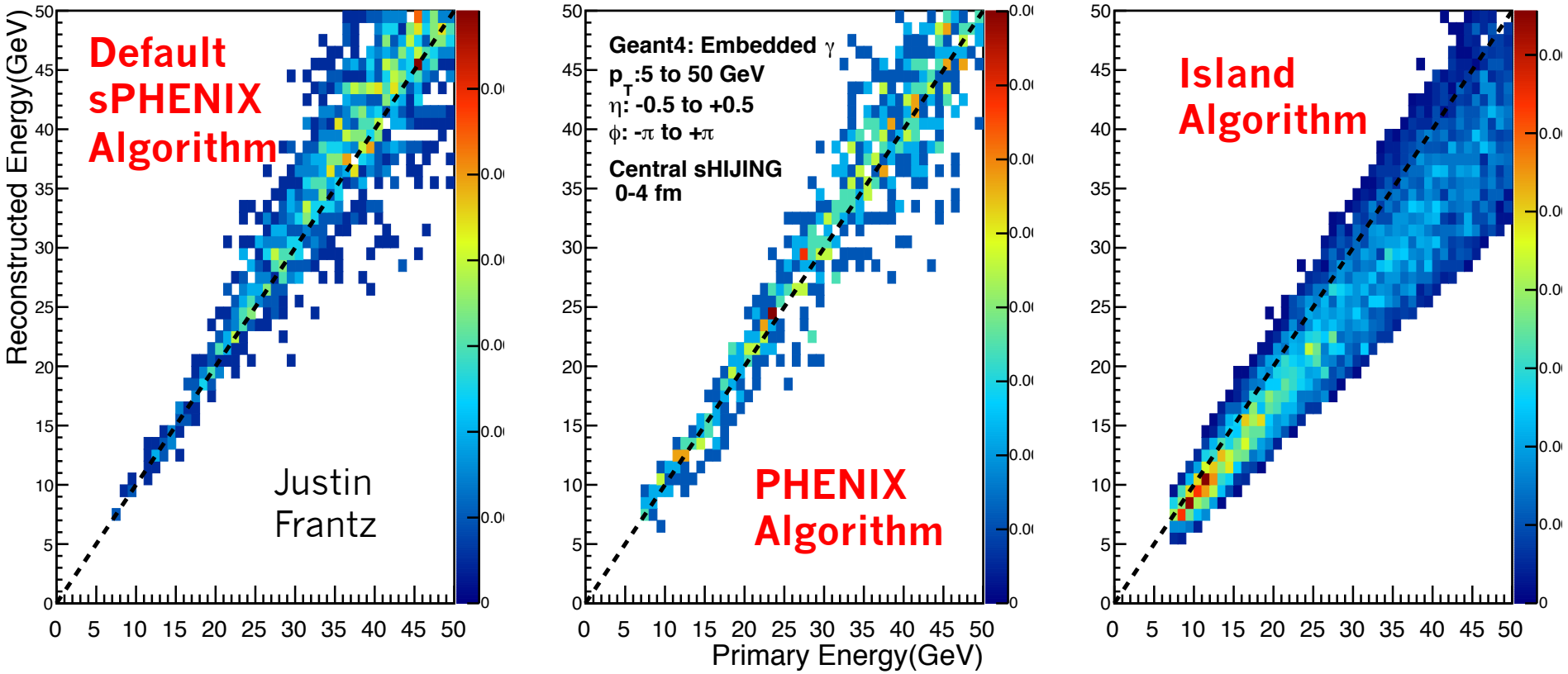
New vs Old Geometry

- Geometry tilt improves the low low E channeling problem
  - Still some low E clusters → remainder consistent with punch through?
- E reco distributions for 35-40 GeV Truth γ



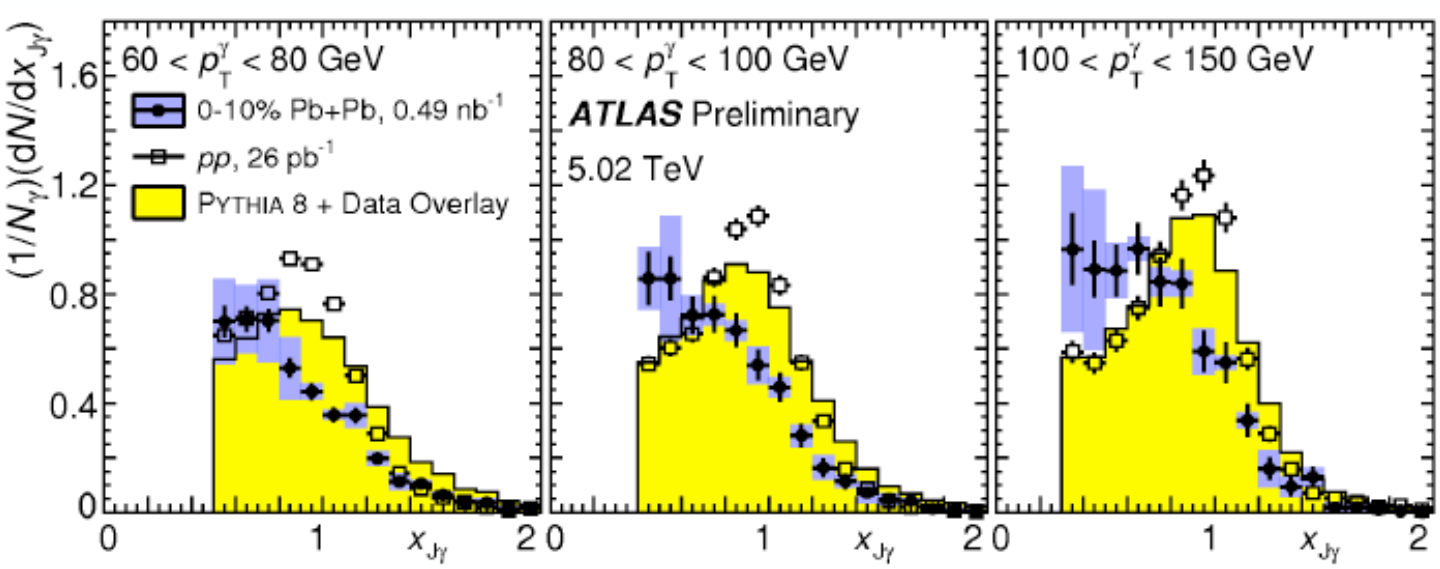


γ Reconstruction in AA



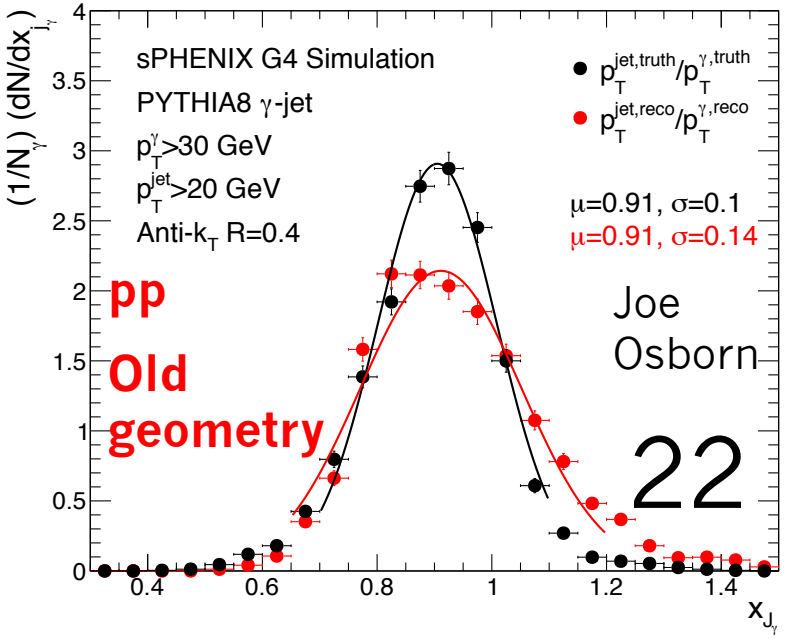
- First γ embedding results with new geometry
  - Clustering algorithms used out of the box, some tuning will be necessary

Jet-to-Photon p_T Balance

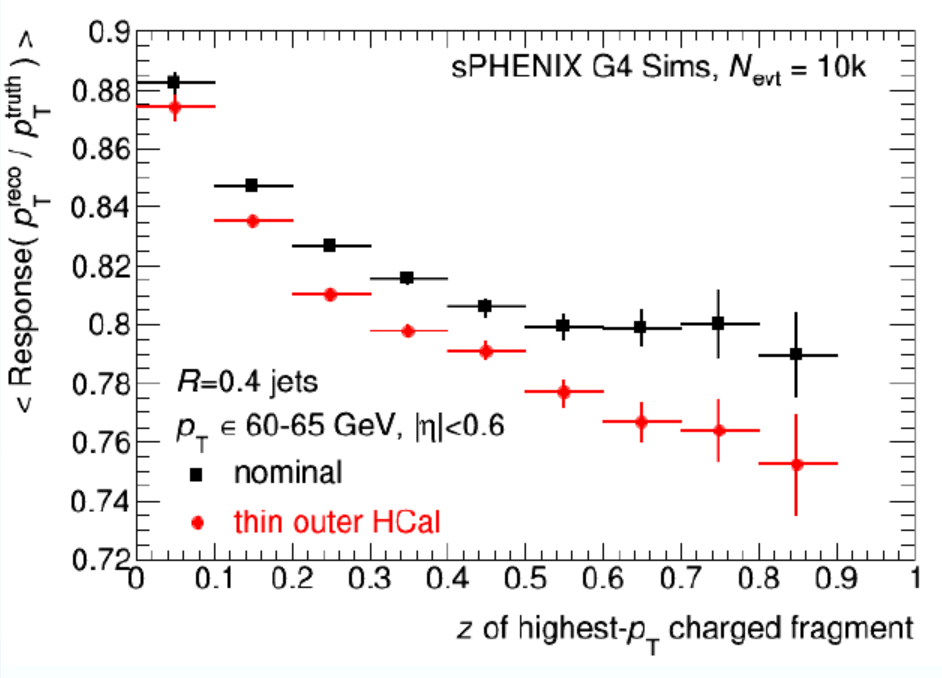


$$X_{J\gamma} = \frac{p_T^\gamma}{p_T^\gamma}$$

- $X_{J\gamma}$ allows a direct comparison between LHC and RHIC
- Predominately quark jets
- Allows a direction connection between pp and AA
  - Repeat study in AA! Stay tuned!!

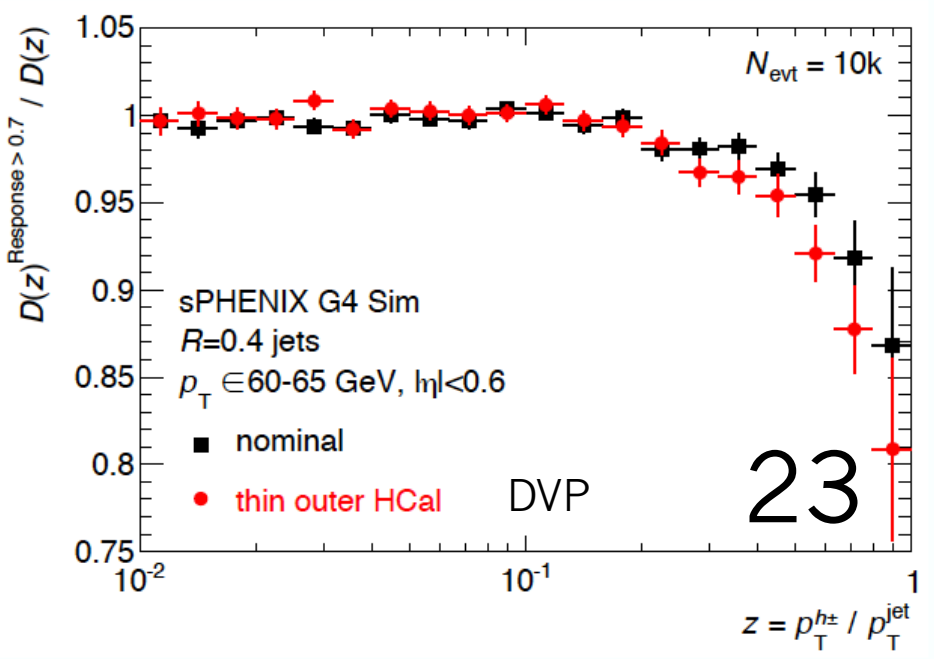


FF measurements



- With the improvements in EMCal and Tracking simulation we can revisit these observables
- Needed the tracking to stabilize
  - Will work closely with Sims team and other TGs

- Jet Subtraction routine will allow studies in HI collisions



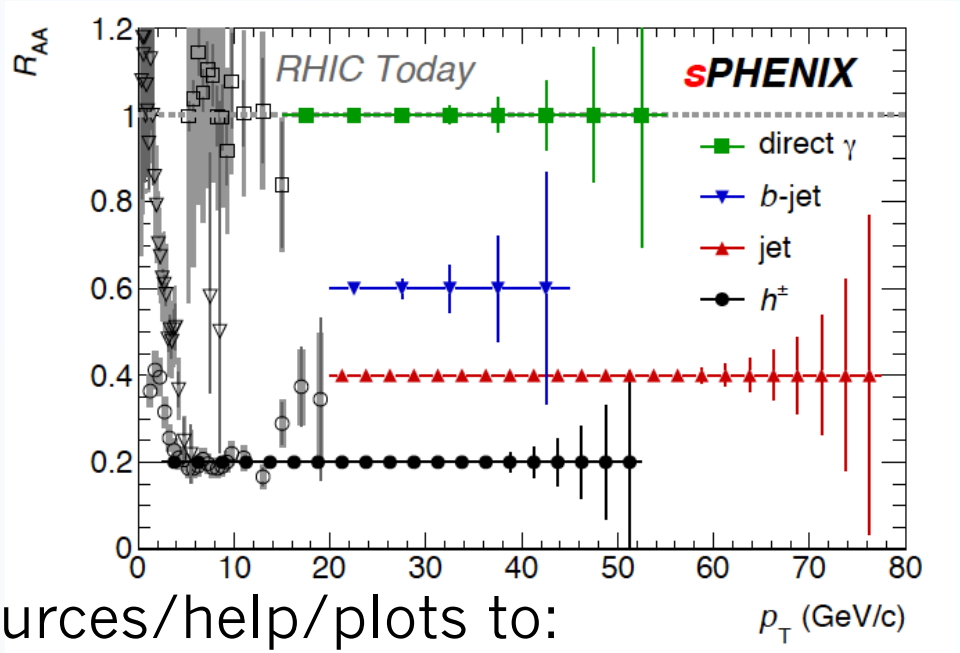
Conclusions/Outlook

- Iterative Atlas-style background subtraction routine has been implemented (few features TBD)
  - ALICE-style background subtraction routine in process
    - Jet median approach → Different philosophy
    - Useful to have multiple choices for systematics
- First jet performance plots in pp and AA with the new EMCal Geometry
  - Replace plots from the MIE
- Photon clustering algorithms applied to new EMCal geometry
  - Some tuning and work will be done over the summer
- Creation of sPhenix Note and additional plots will be completed for necessary reviews

Conclusions/Outlook

Extension of high p_T observables to LHC energies is necessary to fully realize jets as probes of the QGP

- See Jamie's talk for trigger details



- Special thanks for all the resources/help/plots to:
  - Erin Bossard (University of Colorado Boulder)
  - Joe Osborn (University of Michigan)
  - Justin Frantz and the Ohio University Group
  - Dennis Perepelitsa (University of Colorado Boulder)

- Software is shaping up, we'd love to have some volunteers to help generate performance plots now that key components are in place!